



US009319140B2

(12) **United States Patent**
Chen et al.

(10) **Patent No.:** **US 9,319,140 B2**
(45) **Date of Patent:** **Apr. 19, 2016**

(54) **APPARATUS AND METHOD FOR
REGISTERING A COAXIAL NETWORK UNIT
ON AN OPTICAL NETWORK**

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(71) Applicant: **Futurewei Technologies, Inc.**, Plano,
TX (US)

(72) Inventors: **Jim Chen**, Corona, CA (US); **Fanglin
Sun**, Shenzhen (CN); **Li Zhang**,
Shenzhen (CN)

(73) Assignee: **Futurewei Technologies, Inc.**, Plano,
TX (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 168 days.

(21) Appl. No.: **13/691,762**

(22) Filed: **Dec. 1, 2012**

(65) **Prior Publication Data**

US 2013/0142515 A1 Jun. 6, 2013

Related U.S. Application Data

(60) Provisional application No. 61/566,101, filed on Dec.
2, 2011.

(51) **Int. Cl.**
H04J 14/00 (2006.01)
H04B 10/00 (2013.01)
H04B 10/27 (2013.01)

(Continued)

(52) **U.S. Cl.**
CPC **H04B 10/27** (2013.01); **H04Q 11/0067**
(2013.01); **H04B 10/2575** (2013.01); **H04Q**
11/0071 (2013.01); **H04Q 2011/0088** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

Primary Examiner — Ken Vanderpuye

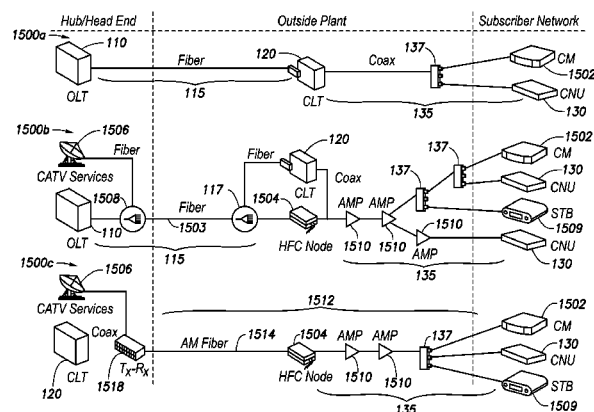
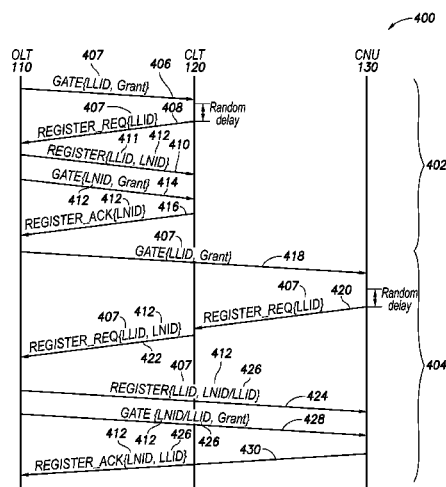
Assistant Examiner — Jai Lee

(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.; Grant
Rodolph; Jonathan K. Polk

(57) **ABSTRACT**

A method comprising receiving a coaxial network unit
(CNU) registration request from a CNU via a coaxial portion
of a network, wherein the registration request is addressed to
an optical line terminal (OLT), and forwarding the CNU
registration request to the OLT via an optical portion of the
network. Included is an OLT comprising a processor config-
ured to receive a registration request including a logical node
identifier (LNID) assigned to a coaxial line terminal (CLT) in
a payload of the registration request, wherein the CLT inter-
mediates between the OLT via an optical portion of a unified
optical-coaxial network and a CNU via an electrical network
portion of the unified optical-coaxial network, assign a logi-
cal link identifier (LLID) to the CNU, and send the LLID to
the CNU via the CLT.

20 Claims, 14 Drawing Sheets



- (51) **Int. Cl.**
H04Q 11/00 (2006.01)
H04B 10/2575 (2013.01)

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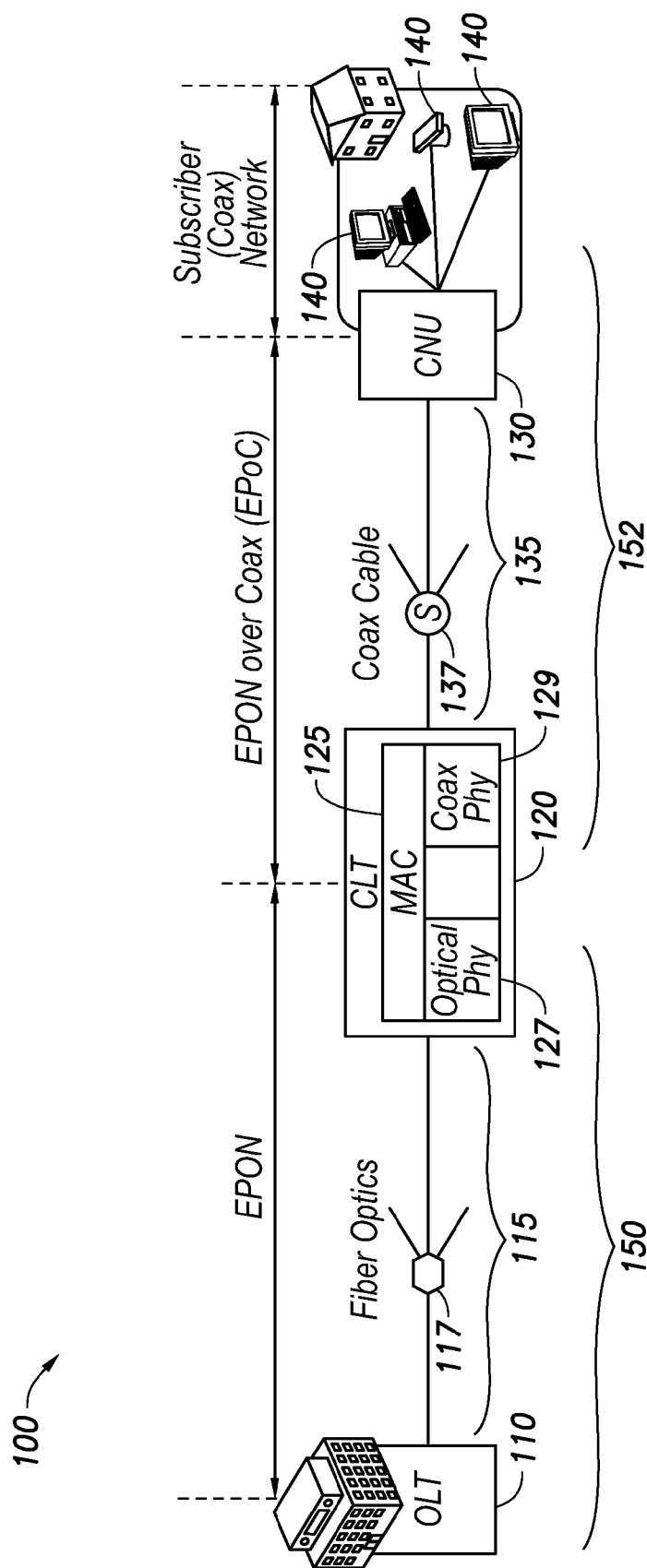


FIG. 1

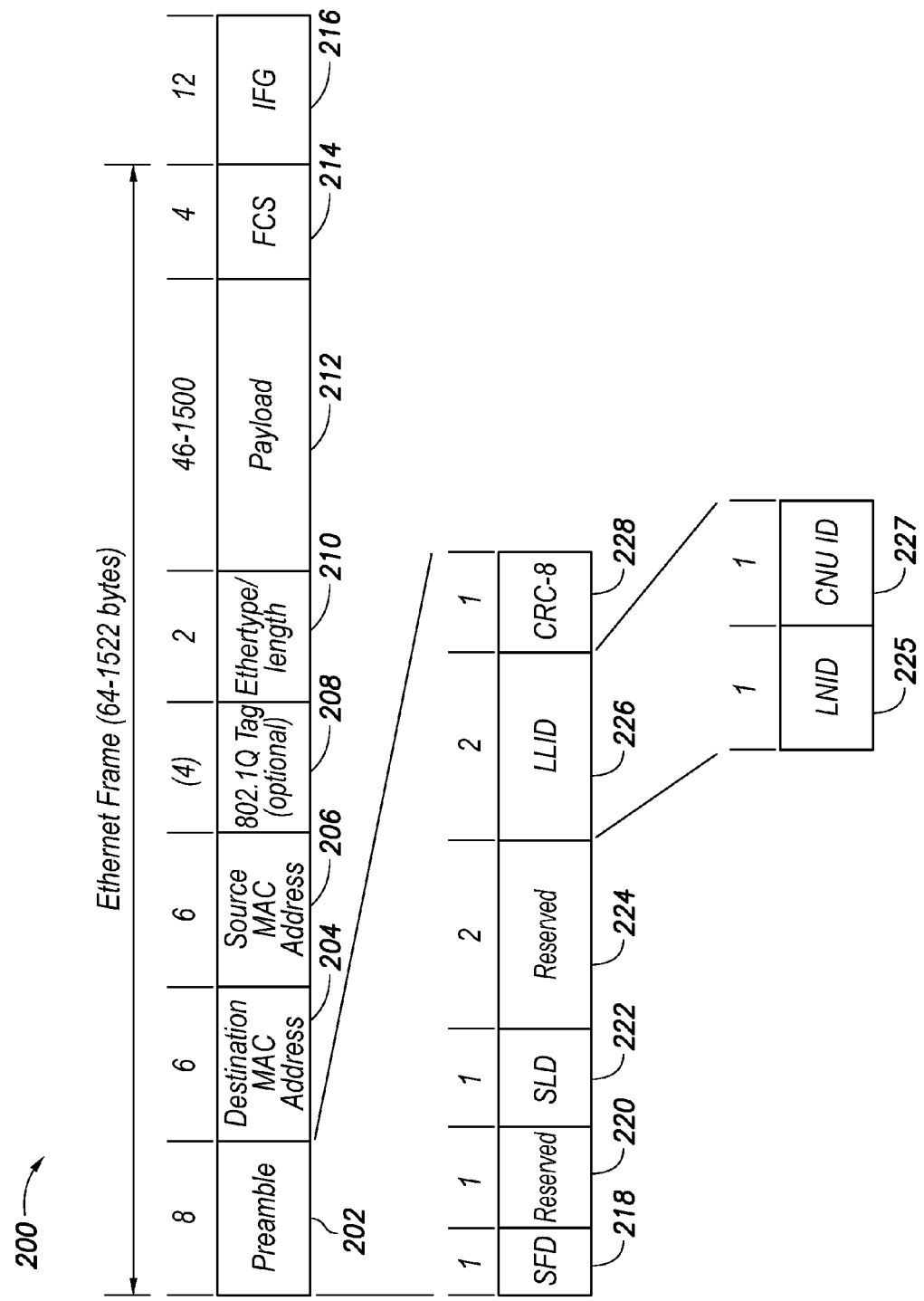


FIG.2

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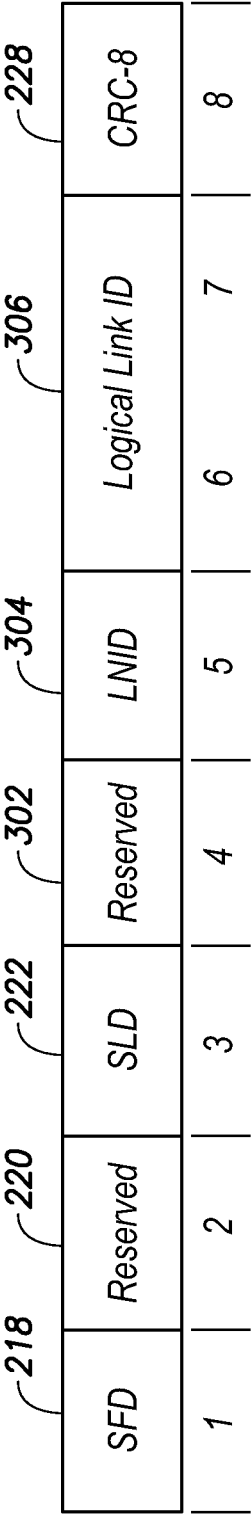


FIG.3

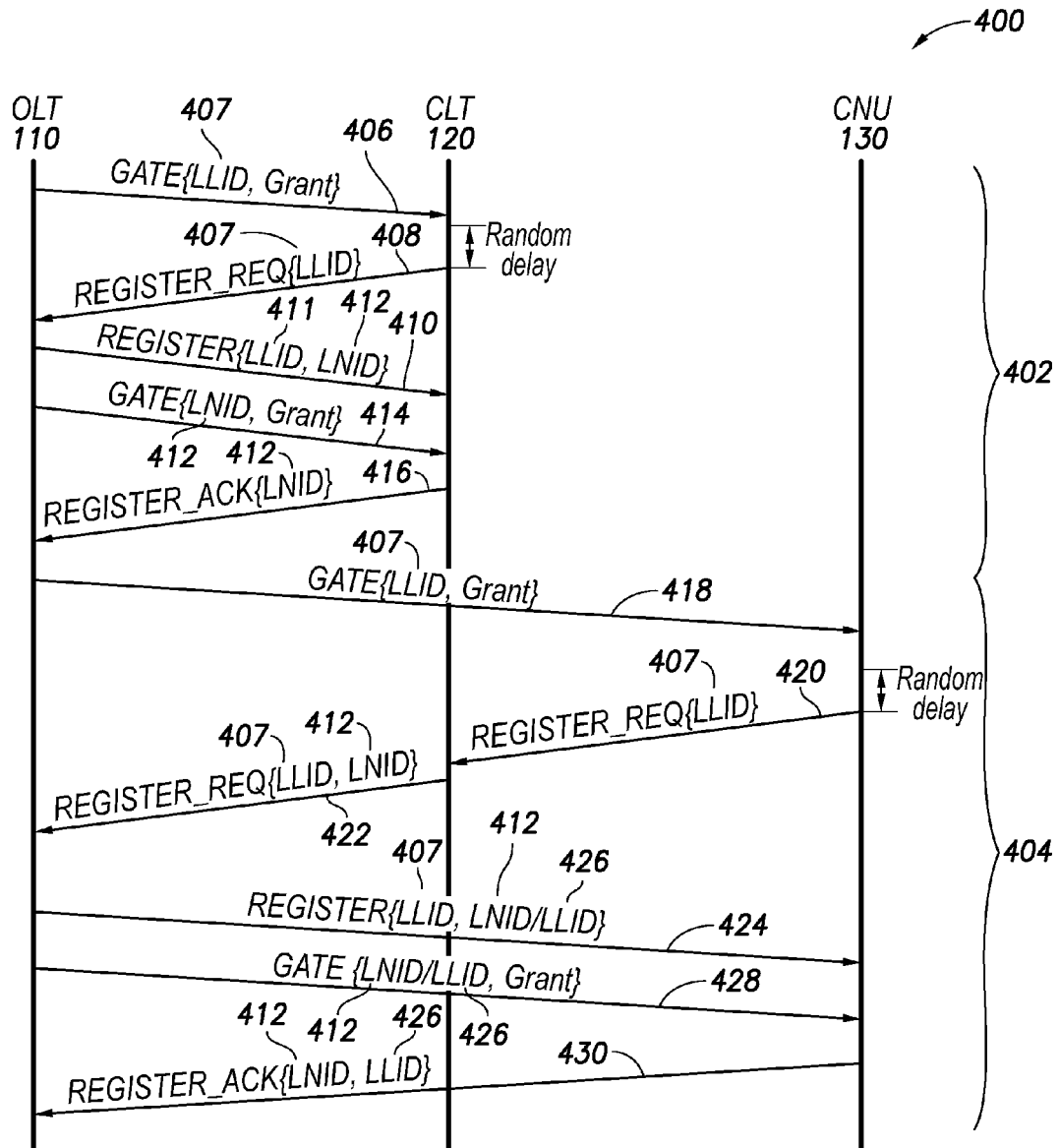
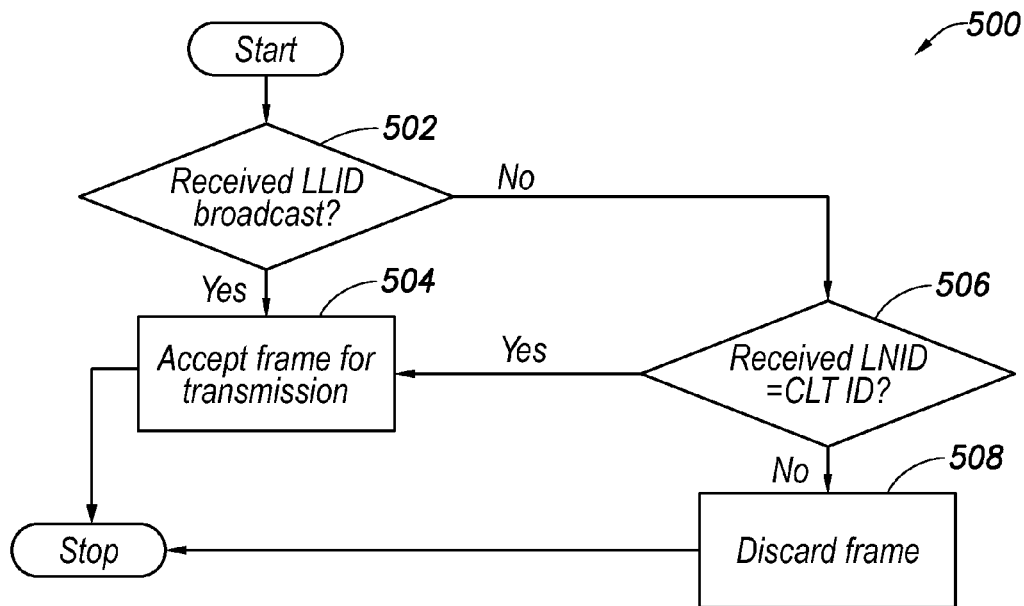
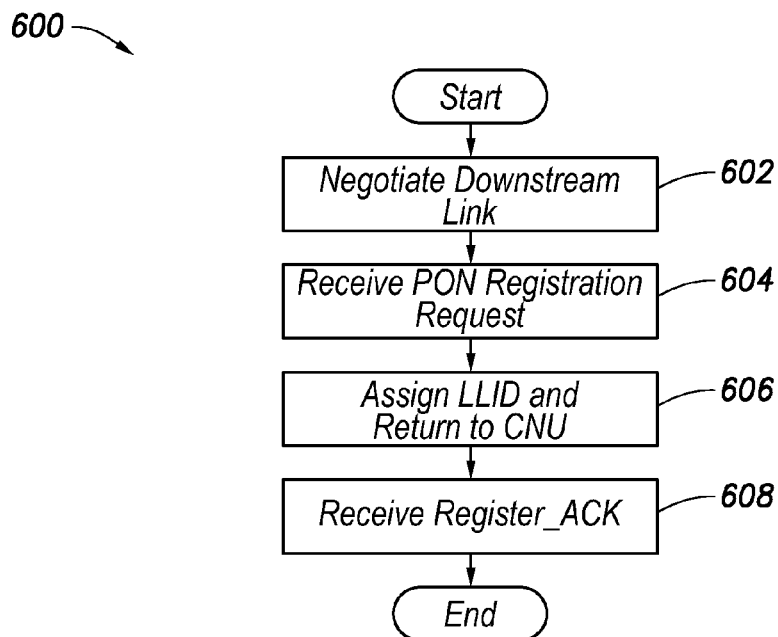
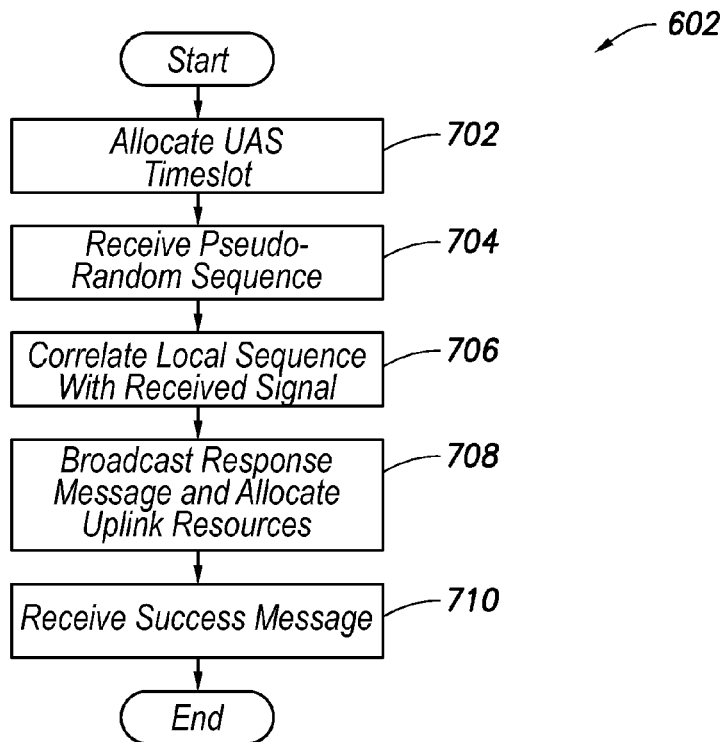
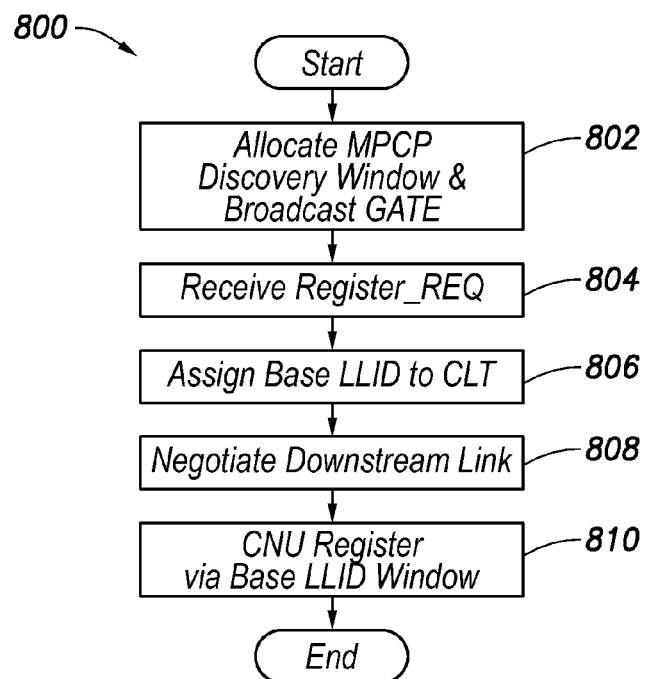


FIG.4

**FIG.5****FIG.6**

**FIG. 7****FIG. 8**

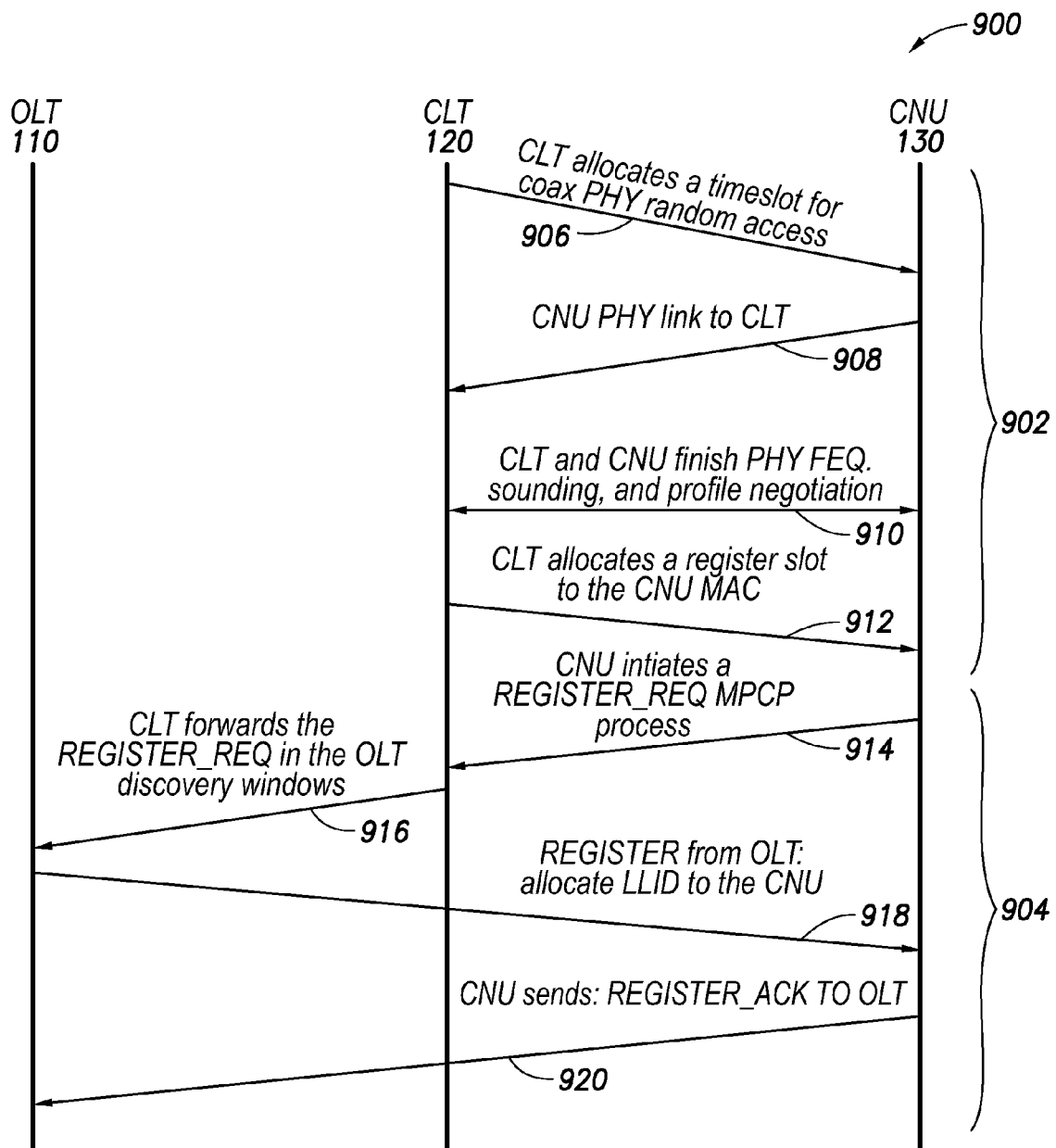


FIG. 9

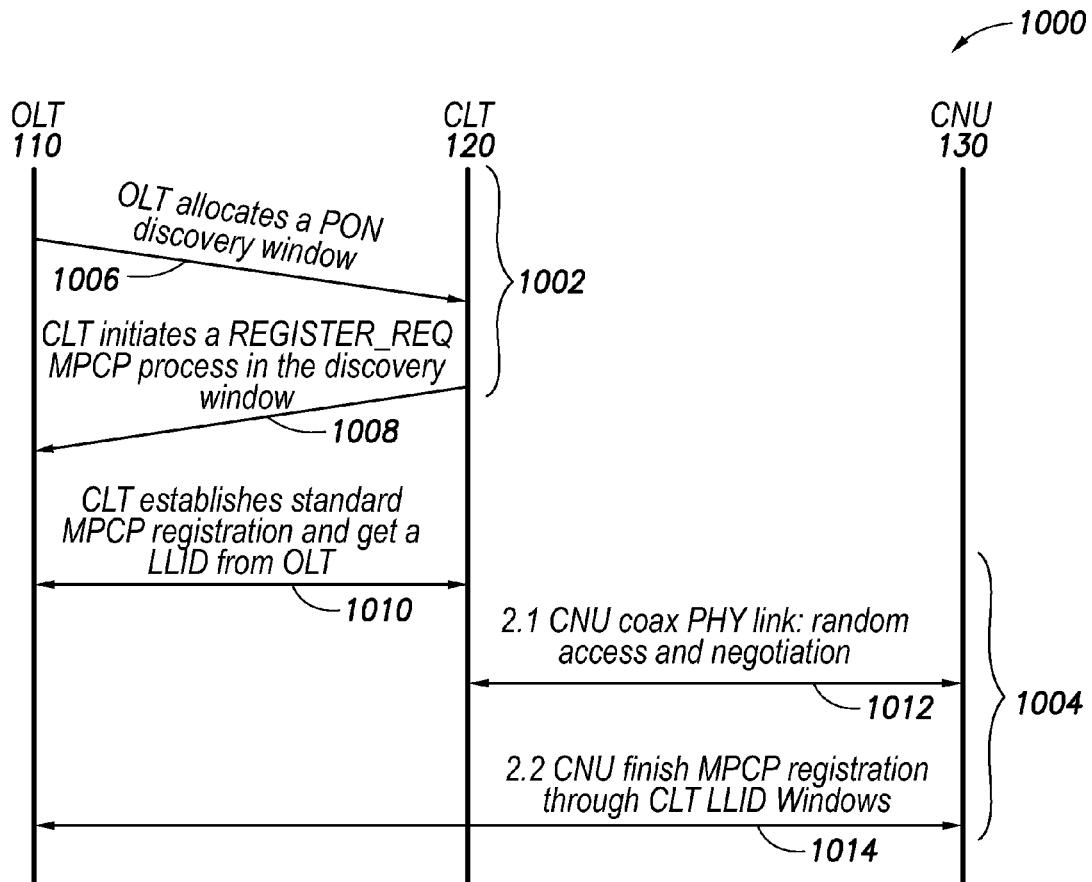
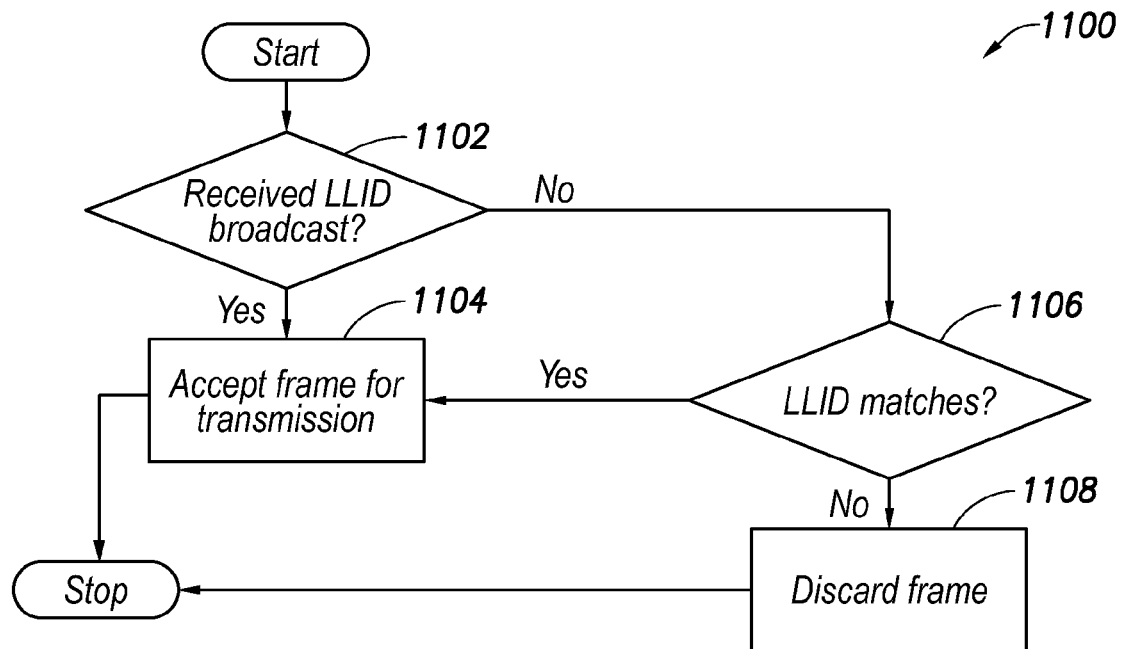
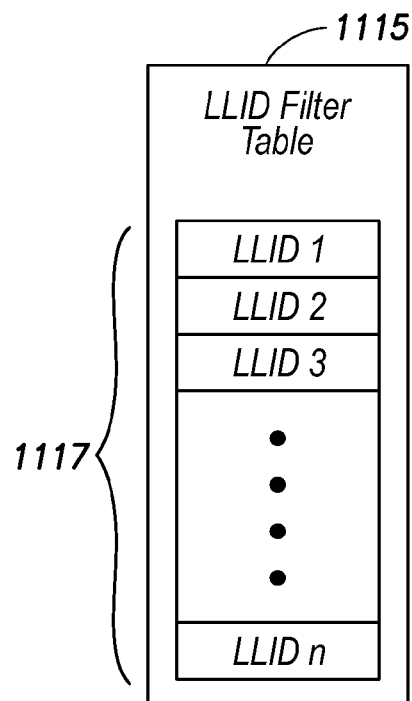


FIG. 10

**FIG. 11****FIG. 12**

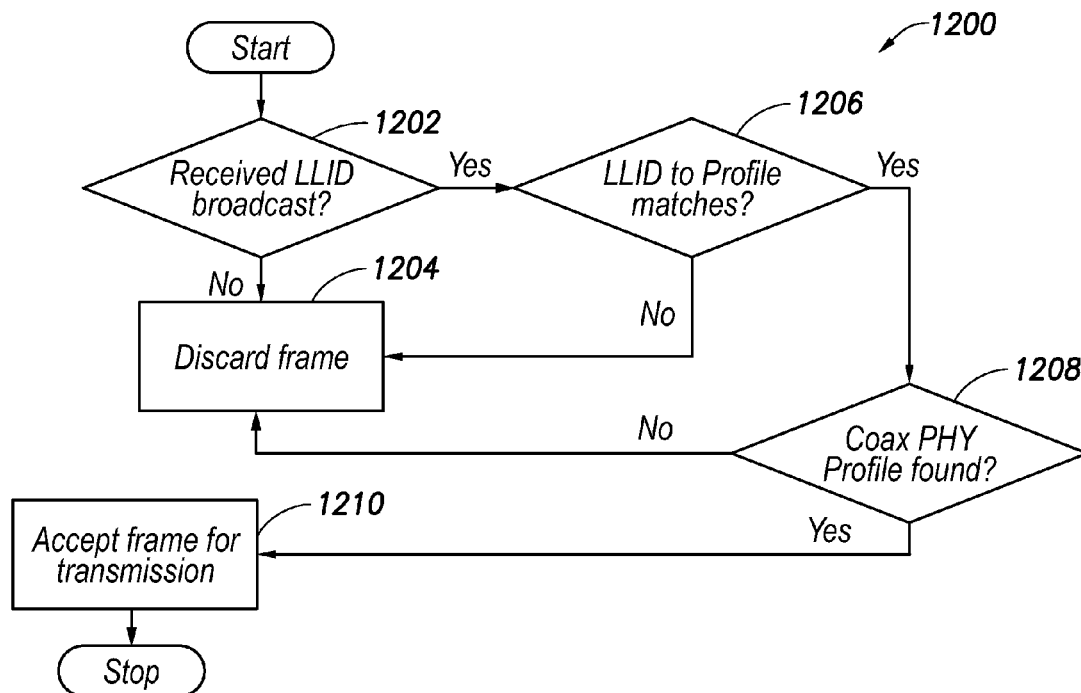


FIG. 13

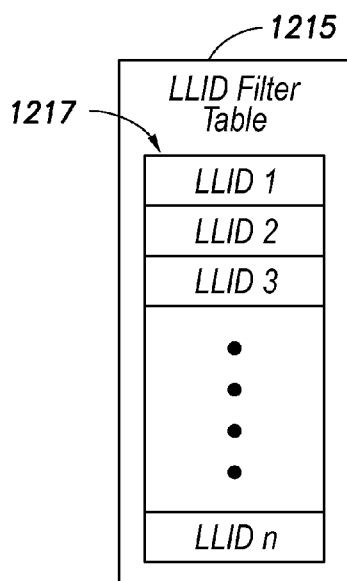


FIG. 14

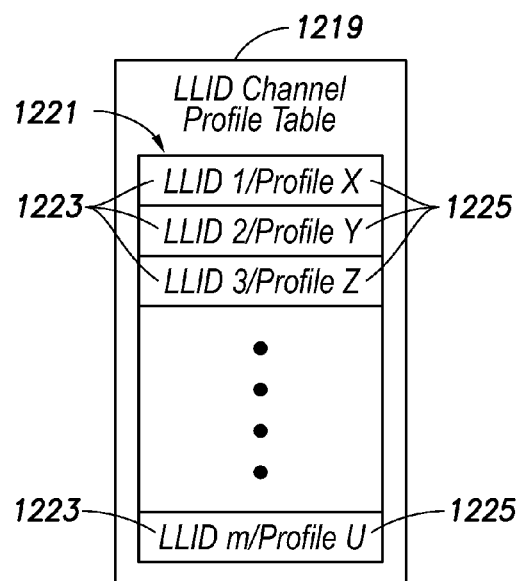
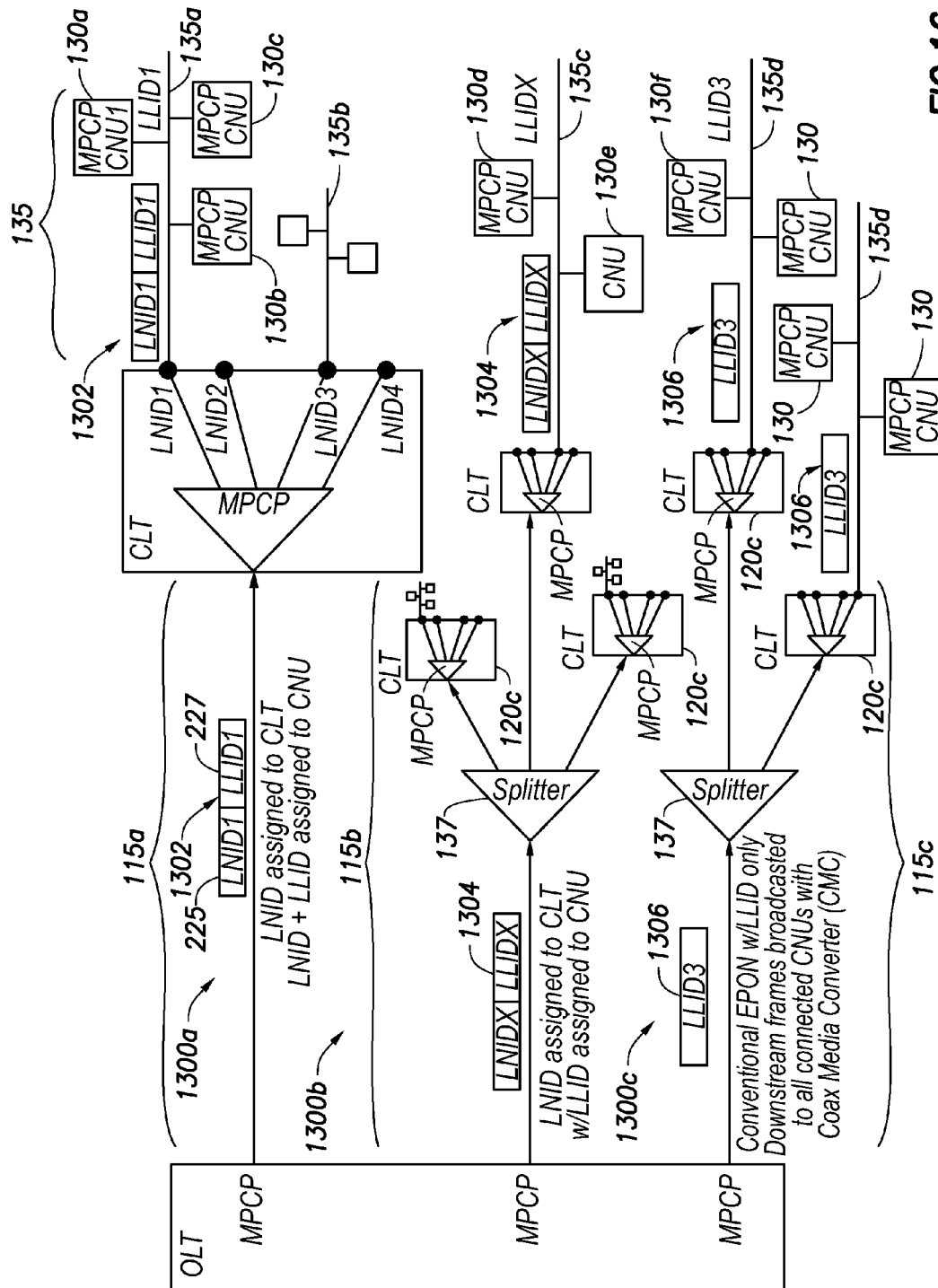


FIG. 15



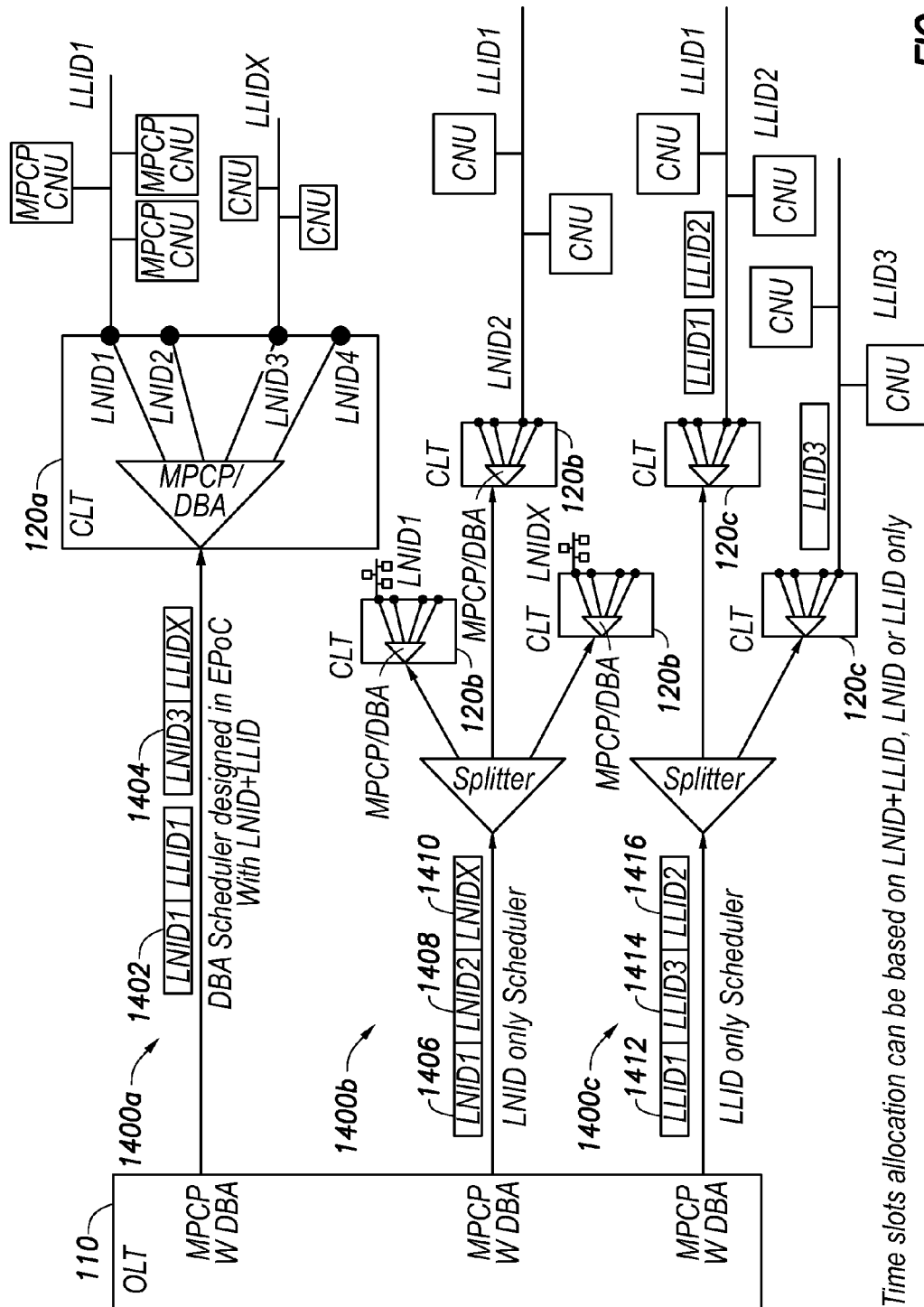


FIG. 17

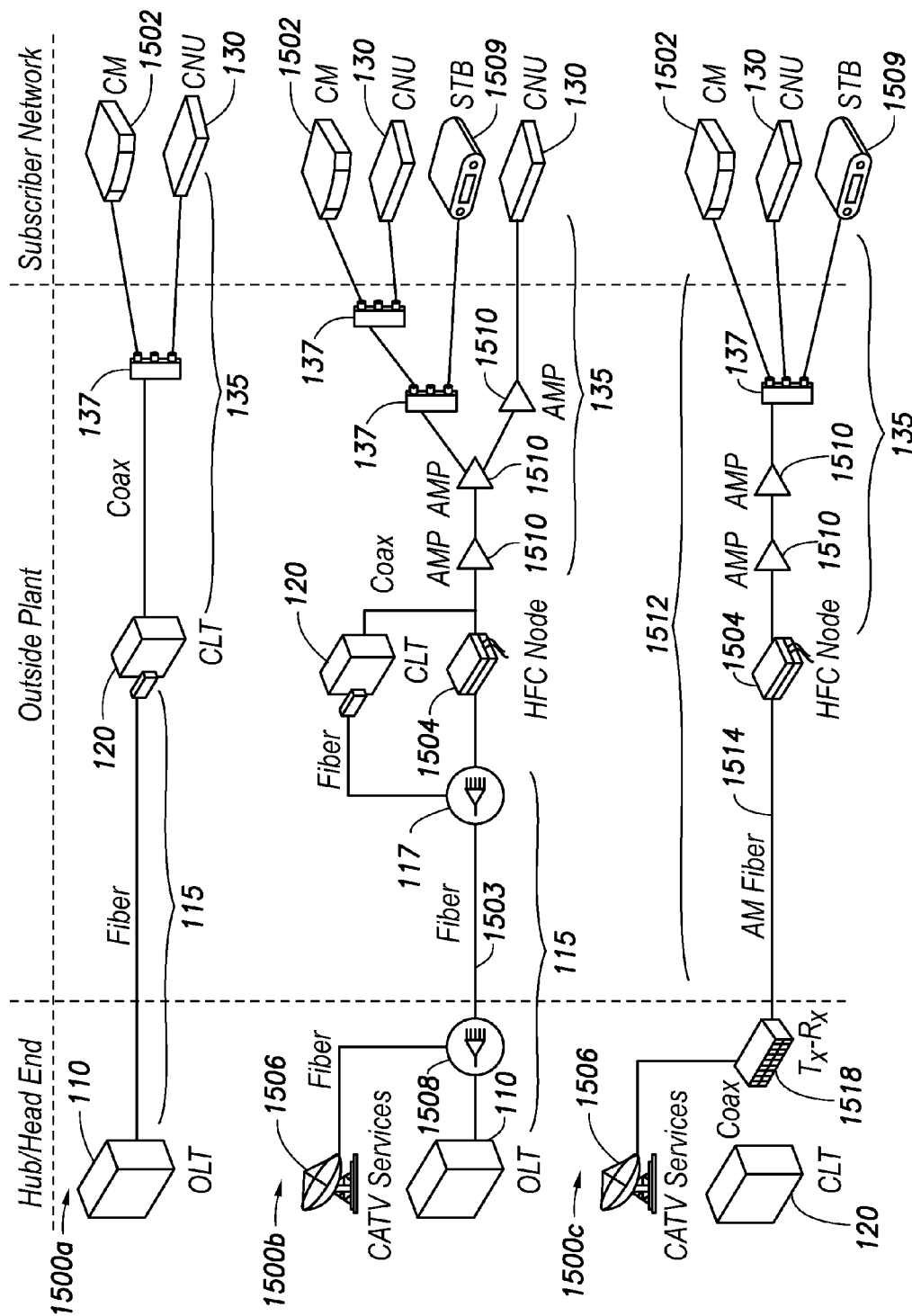


FIG. 18

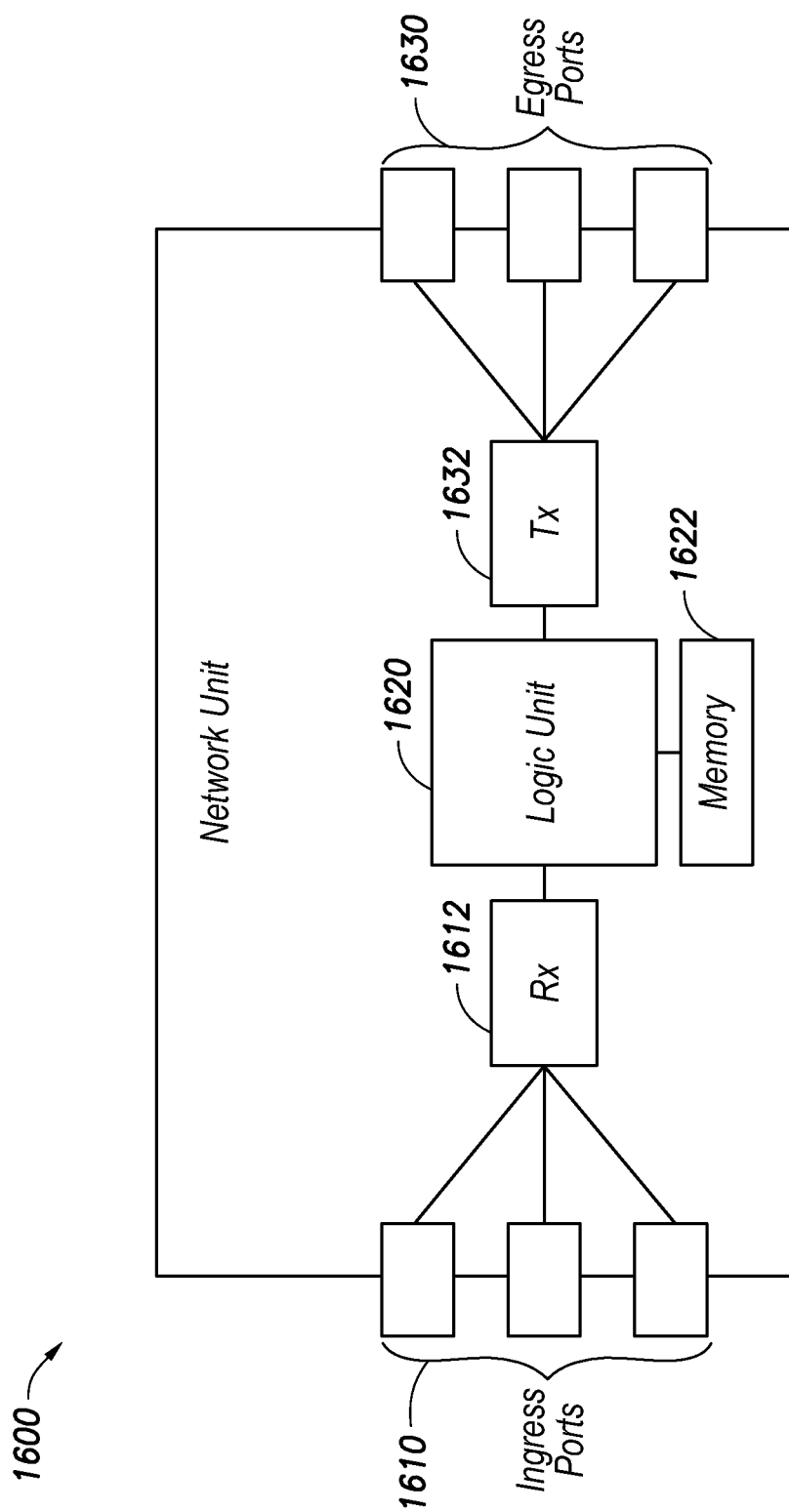


FIG. 19

1

APPARATUS AND METHOD FOR REGISTERING A COAXIAL NETWORK UNIT ON AN OPTICAL NETWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application No. 61/566,101 filed Dec. 2, 2011 by Jim Chen, et al. and entitled "Method of Identifying a Transit Node in an Ethernet Passive Optical Network over Coax Network," which is incorporated herein by reference as if reproduced in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

REFERENCE TO A MICROFICHE APPENDIX

Not applicable.

BACKGROUND

A passive optical network (PON) is one system for providing network access over "the last mile." The PON is a point-to-multi-point (P2MP) network comprised of an optical line terminal (OLT) at the central office, an optical distribution network (ODN), and a plurality of optical network units (ONUs) at the customer premises. Ethernet passive optical network (EPON) is a PON standard developed by the Institute of Electrical and Electronics Engineers (IEEE) and specified in IEEE 802.3ah, which is incorporated herein by reference as if reproduced in its entirety. In EPON, a single fiber can be used for both the upstream and the downstream transmission with different wavelengths. The OLT implements an EPON Media Access Control (MAC) layer for transmission of Ethernet Frames. The Multi-Point Control Protocol (MPCP) performs the bandwidth assignment, bandwidth polling, auto-discovery, and ranging. Ethernet frames are broadcast downstream based on the Logical Link Identifier (LLID) embedded in the preamble frame. Upstream bandwidth is assigned based on the exchange of Gate and Report messages between an OLT and an ONU.

Ethernet over Coaxial (EoC) is a generic name used to describe all technologies which can be used for transmission of Ethernet frames over a unified optical-coaxial network. The name comes from the fact that, except for Data Over Cable Service Interface Specification (DOCSIS), all these technologies have in common that the Ethernet Frames are transmitted in the MAC layer. Different EoC technologies exist, including Multimedia over Coax Alliance (MoCA), G.hn (a common name for a home network technology family of standards developed under the International Telecommunication Union (ITU) and promoted by the HomeGrid Forum), HomePNA Alliance (HPNA), and Home Plug Audio/Visual (A/V), and they have been adapted to run the outdoor coaxial access from an ONU to an EoC Head End with connected Customer Premises Equipment (CPEs) located in the subscriber homes.

There is a rising demand which requires the use of EPON as an access system to interconnect with multiple coaxial cables to terminate the Coaxial Network Units (CNU) located in the subscriber's home with an Ethernet PON over Coaxial (EPoC) architecture. However, none of the above-referenced EoC technologies provides a unique way to iden-

2

tify the EoC Head End that connects the EPON and Coaxial networks. Consequently, there is a need in the art for methods and systems to provide a unique identifier to an EoC Head End (which may also be referred to as a transit node (TN), a Coaxial Media Converter (CMC) or Coaxial Line Terminal (CLT), and those skilled in the art would recognize these as synonymous).

SUMMARY

In an embodiment, the disclosure includes a method comprising receiving a CNU registration request from a CNU via a coaxial portion of a network, wherein the registration request is addressed to an OLT, and forwarding the CNU registration request to the OLT via an optical portion of the network.

In another embodiment, the disclosure includes an OLT comprising a processor configured to receive a registration request including a logical node identifier (LNID) assigned to a coaxial line terminal (CLT) in a payload of the registration request, wherein the CLT intermediates between the OLT via an optical portion of a unified optical-coaxial network and a CNU via an electrical network portion of the unified optical-coaxial network, assign a LLID to the CNU, and send the LLID to the CNU via the CLT.

In yet another embodiment, the disclosure includes A CNU comprising a processor, and a memory coupled to the processor, wherein the memory comprises instructions to cause the processor to receive an access time allocation from a CLT, establish a link between the CNU and CLT on a coaxial portion of a unified optical-coaxial network using the access time allocation, and send a registration request to an OLT via the CLT, wherein the CLT intermediates between the OLT via an optical portion of the unified optical-coaxial network and CNU via the coaxial portion of the unified optical-coaxial network.

These and other features will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of this disclosure, reference is now made to the following brief description, taken in connection with the accompanying drawings and detailed description, wherein like reference numerals represent like parts.

FIG. 1 is a schematic diagram of a unified optical-coaxial network according to an embodiment of the disclosure.

FIG. 2 is a schematic diagram of an Ethernet frame in accordance with an embodiment of the disclosure.

FIG. 3 is a schematic diagram of a portion of an Ethernet frame in accordance with another embodiment of the disclosure.

FIG. 4 is a protocol diagram of a registration protocol in accordance with an embodiment of the disclosure.

FIG. 5 is a flowchart of a process for filtering message frames in accordance with an embodiment of the disclosure.

FIG. 6 is a flowchart of a process for registering a network unit in accordance with an embodiment of the disclosure.

FIG. 7 is a flowchart of a portion of the process of FIG. 6.

FIG. 8 is a flowchart of a process for registering network unit in accordance with another embodiment of the disclosure.

FIG. 9 is a protocol diagram of a registration protocol in accordance with an embodiment of the disclosure.

FIG. 10 is a protocol diagram of a registration protocol in accordance with another embodiment of the disclosure.

FIG. 11 is a flowchart of a process for filtering message frames in accordance with another embodiment of the disclosure.

FIG. 12 is a schematic diagram of an embodiment of a LLID filter table.

FIG. 13 is a flowchart of a process for filtering message frames in accordance with yet another embodiment of the disclosure.

FIG. 14 is a schematic diagram of an embodiment of a LLID filter table.

FIG. 15 is a schematic diagram of an embodiment of a LLID channel profile table.

FIG. 16 is a schematic diagram of downstream message flows in accordance with embodiments of the disclosure.

FIG. 17 is a schematic diagram of an upstream message flows in accordance with embodiments of the disclosure.

FIG. 18 is a schematic diagram of deployments of a unified optical-coaxial network in accordance with embodiments of the disclosure.

FIG. 19 is block diagram of an embodiment of a network unit.

DETAILED DESCRIPTION

It should be understood at the outset that although an illustrative implementation of one or more embodiments are provided below, the disclosed systems and/or methods may be implemented using any number of techniques, whether currently known or in existence. The disclosure should in no way be limited to the illustrative implementations, drawings, and techniques illustrated below, including the exemplary designs and implementations illustrated and described herein, but may be modified within the scope of the appended claims along with their full scope of equivalents.

Disclosed herein are systems, methods, and apparatus to support the unified optical-coaxial network architecture. In one embodiment, this disclosure provides a CLT identifier, referred to as Logical Node Identification (LNID), which may be placed in the preamble field of an EPON frame to uniquely identify a specific CLT between the optical and coaxial portions of the unified optical-coaxial network. The LNID may be placed in the reserved bits of an existing LLID, and can be used to identify a directly connected CLT. In an embodiment, the disclosure provides a mechanism for registering various CNU with the OLT via the CLT. In yet another embodiment, the disclosure provides a mechanism by which the CLT may filter traffic that is not designated to its CNU, thereby reducing the amount of unnecessary traffic on the coaxial portion of the unified optical-coaxial network.

Refer now to FIG. 1 illustrating an embodiment of a unified optical-coaxial network 100 comprising an optical portion 150 and a coaxial (electrical) portion 152. The unified optical-coaxial network 100 may include an OLT 110, at least one CNU 130 coupled to a plurality of subscriber devices 140, and a CLT 120 positioned between the OLT 110 and the CNU 130, e.g., between the optical portion 150 and the coaxial portion 152. The OLT 110 may be coupled via an Optical Distribution Network (ODN) 115 to the CLTs 120, and optionally to one or more ONUs (not shown) in the optical portion 150. The ODN 115 may comprise fiber optics and an optical splitter 117 that couples OLT 110 to the CLT 120 and any ONUs. The CLT 120 may be coupled to the CNU 130 via an electrical distribution network (EDN) 135, which may comprise a cable splitter 137. Although FIG. 1 shows one CLT 120 and one CNU 130, the unified optical-coaxial network 100 may com-

prise any number of CLTs 120 and corresponding CNU 130. The components of unified optical-coaxial network 100 may be arranged as shown in FIG. 1 or any other suitable arrangement.

The optical portion 150 of the unified optical-coaxial network 100 may be similar to a PON in that it may be a communications network that does not require any active components to distribute data between the OLT 110 and the CLT 120. Instead, the optical portion 150 may use the passive optical components in the ODN 115 to distribute data between the OLT 110 and the CLT 120. Examples of suitable protocols that may be implemented in the optical portion 150 include the asynchronous transfer mode PON (APON) and the broadband PON (BPON) defined by the ITU Telecommunication Standardization Sector (ITU-T) G.983 standard, Gigabit PON (GPON) defined by the ITU-T G.984 standard, the EPON defined by the IEEE 802.3ah standard, and the wavelength division multiplexing (WDM) PON (WDM-PON), all of which are incorporated by reference as if reproduced in their entirety.

The OLT 110 may be any device configured to communicate with the CNU 130 via the CLT 120. The OLT 110 may act as an intermediary between the CLTs 120 or CNU 130 and another network (not shown). The OLT 110 may forward data received from the other network to the CLTs 120 or CNU 130 and forward data received from the CLTs 120 or CNU 130 onto the other network. Although the specific configuration of the OLT 110 may vary depending on the type of optical protocol implemented in the optical portion 150, in an embodiment, OLT 110 may comprise an optical transmitter and an optical receiver. When the other network is using a network protocol that is different from the protocol used in the optical portion 150, OLT 110 may comprise a converter that converts the other network protocol into the optical portion 150 protocol. The OLT converter may also convert the optical portion 150 protocol into the other network protocol.

The ODN 115 may be a data distribution system that may comprise optical fiber cables, couplers, splitters, distributors, and/or other equipment. In an embodiment, the optical fiber cables, couplers, splitters, distributors, and/or other equipment are passive optical components. Specifically, the optical fiber cables, couplers, splitters, distributors, and/or other equipment may be components that do not require any power to distribute data signals between the OLT 110 and the CLT 120. It should be noted that the optical fiber cables may be replaced by any optical transmission media in some embodiments. In some embodiments, the ODN 115 may comprise one or more optical amplifiers. The ODN 115 typically extends from the OLT 110 to the CLT 120 and any optional ONUs (not shown) in a branching configuration as shown in FIG. 1, but may be alternatively configured as determined by a person of ordinary skill in the art.

The CLT 120 may be any device or component configured to forward downstream data from the OLT 110 to the corresponding CNU 130 and forward upstream data from the CNU 130 to the OLT 110. The CLT 120 may convert the downstream and upstream data appropriately to transfer the data between the optical portion 150 and the coaxial portion 152. The data transferred over the ODN 115 may be transmitted or received in the form of optical signals, and the data transferred over the EDN 135 may be transmitted or received in the form of electrical signals that may have the same or different logical structure as compared with the optical signals. As such, the CLT 120 may encapsulate or frame the data in the optical portion 150 and the coaxial portion 152 differently. In an embodiment, the CLT 120 includes a media access control (MAC) layer 125 and physical (PHY) layers, corre-

5

sponding to the type of signals carried over the respective media. The MAC layer **125** may provide addressing and channel access control services to the PHY layers. As such, the PHY may comprise an optical PHY **127** and a coaxial PHY **129**. In many embodiments, the CLT **120** is transparent to the CNU **130** and OLT **110** in that the frames sent from the OLT **110** to the CNU **130** may be directly addressed to the CNU **130** (e.g. in the destination address), and vice-versa. As such, the CLT **120** intermediates between network portions, namely an optical portion **150** and a coaxial portion **152** in the example of FIG. 1. As discussed further below, an identifier may be associated with each CLT **120**, and the identifier may uniquely identify the each CLT **120**.

The electrical portion **152** of the unified electrical and coaxial network **100** may be similar to any known electrical communication system. The electrical portion **152** may not require any active components to distribute data between the CLT **120** and the CNU **130**. Instead, the electrical portion **152** may use the passive electrical components in the electrical portion **152** to distribute data between the CLT **120** and the CNU **130**. Alternatively, the electrical portion **152** could use some active components, such as amplifiers. Examples of suitable protocols that may be implemented in the electrical portion **152** include MoCA, G.hn, HPNA, and Home Plug A/V, all of which are incorporated by reference as if reproduced in their entirety.

The EDN **135** may be a data distribution system that may comprise electrical cables (e.g. coaxial cable, twisted wires, etc.), couplers, splitters, distributors, and/or other equipment. In an embodiment, the electrical cables, couplers, splitters, distributors, and/or other equipment are passive electrical components. Specifically, the electrical cables, couplers, splitters, distributors, and/or other equipment may be components that do not require any power to distribute data signals between the CLT **120** and the CNU **130**. It should be noted that the electrical cables may be replaced by any electrical transmission media in some embodiments. In some embodiments, the EDN **135** may comprise one or more electrical amplifiers. The EDN **135** typically extends from the CLT **120** to the CNU **130** in a branching configuration as shown in FIG. 1, but may be alternatively configured as determined by a person of ordinary skill in the art.

In an embodiment, the CNU **130** may be any devices that are configured to communicate with the OLT **110**, the CLT **120**, and any subscriber devices **140**. Specifically, the CNU **130** may act as an intermediary between the CLT **120** and the subscriber devices **140**. For instance, the CNU **130** may forward data received from the CLT **120** to the subscriber devices **140**, and forward data received from the subscriber devices **140** onto the OLT **110**. Although the specific configuration of the CNU **130** may vary depending on the type of unified optical-coaxial network **100**, in an embodiment the CNU **130** may comprise an electrical transmitter configured to send electrical signals to the CLT **120** and an electrical receiver configured to receive electrical signals from the CLT **120**. Additionally, the CNU **130** may comprise a converter that converts the electrical signal into electrical signals for the subscriber devices **140**, such as signals in the asynchronous transfer mode (ATM) protocol, and a second transmitter and/or receiver that may send and/or receive the electrical signals to the subscriber devices **140**. In some embodiments, CNU **130** and coaxial network terminals (CNTs) are similar, and thus the terms are used interchangeably herein. The CNU **130** may be typically located at distributed locations, such as the customer premises, but may be located at other locations as well.

6

The subscriber devices **140** may be any devices configured to interface with a user or a user device. For example, the subscribed devices **140** may include desktop computers, laptop computers, tablets, mobile telephones, residential gateways, televisions, set-top boxes, and similar devices.

Refer now to FIG. 2 illustrating an Ethernet frame **200** in accordance with one embodiment of the disclosure. Frame **200** begins with an 8-byte Preamble **202**. Following the Preamble **202** are a 6-byte destination MAC address **204**, a 6-byte source MAC address **206**, an optional 4-byte IEEE 802.1Q Tag **208**, a 2-byte Ethertype/length **210**, a 46-1,500-byte Payload **212**, and a 4-byte Frame Check Sequence (FCS) **214**, all of which are well known in the art. An inter-frame gap (IFG) **216** may be 12 bytes in length and may be positioned between successive Ethernet frames.

In accordance with one embodiment of the disclosure, the preamble **202** may be further understood by referring to the “exploded” view in FIG. 2, which illustrates six fields: a one-byte start-of-frame delimiter (SFD) **218**, a one-byte first reserved field **220**, a one-byte start-of-LLID delimiter (SLD) **222**, a two-byte second reserved field **224**, a two-byte LLID **226**, and an eight bit Cyclical Redundancy Check (CRC-8) **228**. The LLID **226** may be a logical identifier assigned to a device (e.g. the OLT **110**, the CLT **120**, or the CNU **130**) or a port within a device. Thus, one device may have multiple LLIDs **226**. The LLID **226** may also be called a coaxial medial converter (CMC) ID or an optical conversion unit (OCU) ID. The LLID **226** may be used by a device to distinguish frames addressed to the device from frames addressed to other devices. The first bit of the LLID **226** may comprise a mode bit that is used to select the transmission mode of the frame, i.e. a unicast transmission or broadcast transmission. The other fields in the Ethernet frame **200** are well known in the art.

In accordance with an embodiment of the disclosure, an “exploded” view of the LLID **226** illustrates a 1-byte LNID **225** and a 1-byte CNU ID **227**. The LNID **225** may be a logical identifier assigned to an intermediary device within the unified optical-coaxial network **100** (e.g. the CLT **120**), and may occupy the first eight bits of LLID **226**. The one-byte CNU ID **227** may be a logical identifier assigned to a CNU **130** or a port within a CNU **130**, and may occupy the final eight bits of the LLID **226**.

Refer now to FIG. 3 illustrating a Preamble field **300** in accordance with another embodiment of the disclosure. Similar to the Preamble **202** in FIG. 2, the Preamble **300** begins with the SFD **218** followed by the first reserved field **220** and the SLD **222**. The second reserved field **302** comprises one byte and is followed by a one-byte LNID **304**. Thus, in the embodiment of FIG. 3, the LNID **304** is embedded in the second byte of the first reserved field **224** in the Ethernet frame preamble **202** as depicted in FIG. 2. Returning to FIG. 3, the next field, LLID **306**, may be two bytes in length and may comprise the LLID value and perhaps the CNU ID **227**. The preamble **300** may conclude with the CRC-8 **228**.

Note that the two embodiments illustrated in FIGS. 2 and 3 are examples by which an LNID value may be embedded in an Ethernet frame. It would be understood by those skilled in the art that any available field in the preamble or the frame may be used, and such alternatives would fall within the spirit and scope of the claimed inventions. Also, the order of the fields in FIGS. 2 and 3 is illustrative of an Ethernet frame in accordance with IEEE 802.3. However, the principles of the disclosure are not limited to a particular frame architecture, and other predetermined message formats may be used therewith. Likewise, the respective lengths of the fields are similarly illustrative, and other predetermined field lengths in

accordance with other message formats may be used in alternative embodiments, and such embodiments would lie within the spirit and scope of the claimed inventions.

To further appreciate identification of a CLT in a unified optical-coaxial network, refer now to FIG. 4 illustrating a registration protocol 400 in a unified optical-coaxial network in accordance with an embodiment of the disclosure in which an OLT 110 discovers and registers both the CLT 120 and the CNU 130. Registration protocol 400 illustrates an embodiment having two stages: CLT registration stage 402 and CNU registration stage 404. In CLT registration stage 402, the CLT 120 is registered with the OLT 110, and in CNU registration stage 404, the CNU 130 is registered with the OLT 110.

Referring first to CLT registration stage 402, the OLT 110 may broadcast a Gate message 406. The payload of Gate message 406 may include a Grant allocating a discovery window, e.g. a timeslot whereby a node, such as CLT 120, receiving the broadcast message and desiring to register with the OLT 110 may transmit a registration message. The CLT 120, desiring to register with the OLT 110, may respond with a registration request message, Register_Req 408, when the discovery window opens. Register_Req 408 may comprise the LLID 407 and may be sent after the expiry of a random delay to mitigate contentions between a plurality of CLTs 120 attempting to register with the OLT 110. The OLT 110 may respond with a registration message, Register 410, which may provide the CLT 120 with identification parameters. In the embodiment shown in FIG. 4, Register 410 includes the LNID 412 assigned to CLT 120, and optionally the LLID 411 (a unicast LLID for the CLT 120). The LNID 412 may be sent to CLT 120 in a payload or other predetermined portion of the message. Register 410 may be transmitted to the CLT 120 on a unicast channel and include a unicast LLID 411 in a preamble or other predetermined portion of Register 410.

Having received Register 410 including LNID 412, the CLT 120 can now be identified using LNID 412. Thus, OLT 110 may allocate a timeslot for the CLT 120 to return a registration acknowledgement by sending Gate 414 containing a timeslot grant and the assigned LNID 412, for example in a preamble or other predetermined field of Gate 414. When the timeslot allocated in Gate 414 opens, the CLT 120 may return a registration acknowledgement message, Register_Ack 416, with the LNID 412 to OLT 110, completing the registration of CLT 120. Further, CLT 120 may use LNID 412 to recognize and/or filter messages broadcast by the OLT 110 and which are addressed to it or to one or more downstream nodes, e.g. CNU 130 and/or subscriber devices 140 (see FIG. 1), as will be described further below.

Turning now to CNU registration stage 404, the OLT 110 may broadcast Gate 418 to allocate a timeslot to CNU 130. The Gate 418 may comprise the LLID 407 (a broadcast LLID for the OLT 110) and the timeslot grant. The CNU 130 may desire to register with OLT 110, and as such may return a registration request, Register_Req 420, which may comprise the LLID 407. The CLT 120 may insert the assigned LNID 412 in a payload or other predetermined field of Register_Req 420 and may forward the revised message, Register_Req 422, to the OLT 110. The OLT 110 may send a registration message, Register 424, to the requesting CNU 130. Register 424 may include identification parameters. For example, the OLT 110 may assign LLID 426 to the requesting CNU 130, and may include the LLID 426, the LLID 407, and the LNID 412 in Register 424. The OLT 110 may then allocate a timeslot to the requesting CNU 130 via Gate 428. Gate 428 may include the LNID 412 and optionally the LLID 426 in a preamble field or other predetermined field and the timeslot grant in the payload. Registration of the requesting CNU 130 completes

when the OLT 110 receives the registration acknowledgment, Register_Ack 430, from the CNU 130.

Note that for simplicity, the embodiment of FIG. 4 has been described in the context of the registration of a CLT 120 and assigning a single LNID 412 thereto. However, it would be recognized by those skilled in the art that a CLT 120 could request registration of multiple LNIDs 412. For example, as described in conjunction with FIG. 1, CLT 120 may be coupled to a plurality of CNUs 130 via the EDN 135. In such an embodiment, the CLT 120 may request assignment and registration of an LNID for each of the connected coaxial cables. In an alternative embodiment, the CLT registration stage 402 and the CNU registration stage 404 may be reversed. In another alternative embodiment, the CLT 120 may obtain from the OLT 110 several LLIDs and/or timeslot grants from the CNUs 130, and distribute the LLIDs and timeslot grants to the CNUs 130 without assistance from the OLT 110. In such a case, the CLT 120 may report doing so to the OLT 110.

To further appreciate an embodiment of a CLT equipped with an assigned LNID, consider FIG. 5, which depicts a flowchart of a process 500 for filtering frames in accordance with an embodiment of the disclosure. The process 500 may be implemented at a CLT or any other intermediate node. The process 500 begins at decision block 502 where the process 500 determines whether the LLID in the received frame is a broadcast LLID. A broadcast LLID may be an LLID intended for all devices (e.g. all CNUs) in the unified optical-coaxial network. If the LLID is a broadcast LLID, then process 500 falls through the "Yes" branch to block 504 where the process 500 accepts the frame for transmission to one or more downstream CNUs, e.g. CNUs 130 in FIG. 1. In other words, the frame is not filtered or otherwise prevented from reaching the CNU at the CLT. The determination in step 502 may be made for example by testing the value of mode bit of LLID 226, FIG. 2. For example, a value of 1 for the mode bit represents a broadcast LLID in an embodiment of an Ethernet frame in accordance with IEEE 802.3. Returning to block 502, if the LLID in the received frame is not a broadcast LLID, the process 500 proceeds by the "No" branch to decision block 506. At block 506, the LNID in the received frame (e.g. LNID 225 in LLID 226) is reviewed to determine whether the received LNID equals the LNID assigned to the CLT. If the received LNID equals the LNID assigned to the CLT, then the process 500 proceeds by the "Yes" branch to block 504 where the frame is accepted for transmission. Returning to block 506, if the received LNID does not equal the LNID assigned to the CLT, the process 500 proceeds to block 508 where the frame is discarded. Note that block 504 is described in the context of an embodiment of a frame preamble as shown in and described in conjunction with FIG. 2, e.g. Preamble 202. In an embodiment of a message frame in which the an LNID is contained in another predetermined field of the frame, such as a Preamble 300 in FIG. 3, the corresponding test in block 504 would be readily apparent to those skilled in the art. Further, as discussed hereinabove in conjunction with FIG. 4, in alternative embodiments a CLT may register multiple LNIDs and the corresponding embodiment of the test in decision block 506 would be readily apparent of those skilled in the art.

Refer now to FIG. 6, which is a flowchart of a process 600 for registering a network unit, such as a CNU, on a network in accordance with an embodiment of the disclosure. In step 602, the CLT (e.g. a CLT 120) having a connected network unit (e.g. CNU 130) to be registered, negotiates and established a downstream link with the network unit. For example, in an embodiment in accordance with FIG. 1, the downstream

link may be established via the coaxial PHY **129**. The negotiation of the downstream link will be described further in conjunction with FIG. 7. Next, in step **604**, the network unit sends an MPCP registration request upstream to the CLT via the link established in step **602**. The CLT passes the registration request through to the OLT, (e.g. OLT **110**) in a discovery window allocated by the OLT as previously described. In step **606**, the OLT assigns a LLID to the network unit and returns the LLID to the registering CNU via an MPCP register message, also described hereinabove. The network unit responds with a Register-Ack message back to the OLT, step **608**, completing the registration of the network unit.

Refer now to FIG. 7, where the negotiation of the downstream link between the CLT and CNU, e.g. step **602** in FIG. 6, is described further. In step **702**, the CLT allocates an Uplink Access Sequence (UAS) timeslot to a network unit to be registered. In step **704**, the network unit selects a pseudo-random sequence with a unique ID and returns it to the CLT via the UAS timeslot. The CLT correlates the received signal with local sequences in step **706** and, upon affirming a sequence, broadcasts a response message with the sequence ID, and allocates uplink resources in step **708**. On receipt of the message broadcast in step **708**, the CNU transmits a success message to the CLT in step **710**.

FIG. 8 is a flowchart of a network unit registration process **800** in accordance with another embodiment of the disclosure. In step **802**, an OLT allocates an MPCP discovery window and broadcasts a Gate message. In step **804**, the CLT, desiring to register, returns an MPCP register request message in the discovery window, as described hereinabove. The OLT assigns a LLID to the CLT, which may be the base LLID for the coaxial portion at step **806**. Step **806** may use the registration message protocol described in conjunction with the embodiment of FIG. 4. In step **808**, the CLT and downstream network unit, e.g. a CNU **130**, negotiate a coaxial PHY link as described in conjunction with FIG. 7. In step **810**, the network unit registers with the OLT via the LLID assigned in step **806** using LLID windows associated therewith, rather than MPCP discovery windows. Thus, for example, in an embodiment as set forth in FIG. 1, CNU **130** MPCP registration may be completed in the optical portion.

Refer now to FIG. 9 which depicts a schematic diagram of a registration protocol **900** in accordance with an embodiment of the disclosure. Registration protocol **900** may utilize the steps illustrated in the processes described in conjunction with FIGS. 6 and 7. Also, registration protocol **900** will be described in the context of unified optical-coaxial network **100** shown in FIG. 1; however, it will be understood by those skilled in the art that the principles set forth herein are not limited to the embodiment illustrated therein.

Registration protocol **900** may be comprised of a CNU coaxial access portion **902** whereby a CNU **130** establishes a connection on a coaxial portion of a unified optical-coaxial network, e.g. coaxial portion **152**, FIG. 1, to a CLT **120**, and a PON registration portion **904**.

Considering first coaxial access portion **902**, a CLT **120** broadcasts a message **906** allocating a time slot for a random access on the coaxial portion **152**. A CNU **130**, desiring to register with an OLT **110**, responds with a message **908** initiating a PHY link to the CLT **120**. CLT **120** and the CNU **130** exchange messages **910** completing the negotiation of the link channel profile. With the link established, CLT **120** sends a message **912** allocating a registration slot, i.e. a time window to the CNU **130** MAC (not shown in FIG. 1) for initiating its registration request.

Considering now PON registration portion **904**, CNU **130** transmits a registration request **914** to OLT **110** via CLT **120**

using the time slot allocated in message **912**. CLT **120** forwards the registration request upstream, message **916**, when a discovery window opens on the optical portion **150** of the network. OLT **110** returns a REGISTER message **918** allocating an LLID to the requesting CNU **130**, and the CNU **130** returns a REGISTER_ACK message **920** to OLT **110**.

Refer now to FIG. 10 which depicts a schematic diagram of a registration protocol **1000** in accordance with an embodiment of the disclosure. Registration protocol **1000** may utilize the steps illustrated in the processes described in conjunction with FIG. 8. Also, registration protocol **1000** will be described in the context of unified optical-coaxial network **100** shown in FIG. 1; however, it will be understood by those skilled in the art that the principles set forth herein are not limited to the embodiment illustrated therein.

Registration protocol **1000** may comprise a CLT registration portion **1002** and a CNU registration portion **1004**. Considering first the registration portion **1002**, a CLT **110** sends a discovery window message **1006** on the optical portion **150** of a unified optical-coaxial network **100**. A CLT **120** initiates a REGISTER_REQ message **1008** in the discovery window. The CLT **120** and OLT **110** exchange MCPC registration messages **1010** and the CLT **120** is allocated an LLID which may be a base LLID for the coaxial portion **152** of the unified optical-coaxial network **100**.

Considering now CNU registration portion **1004**, the CLT **120** and CNU **130** exchange messages **1012** bringing up a link on the coaxial portion **152** of the network. CNU **130** may then complete registration using the LLID windows, message exchange **1014**, rather than discovery windows. In this way MPCP registration can be completed on the optical portion **150** of the unified optical-coaxial network **100** to mitigate contention.

Refer now to FIG. 11 illustrating flowchart of a process **1100** for filtering message frames in accordance with another embodiment of the disclosure. Process **1100** will be described in the context of unified optical-coaxial network **100** shown in FIG. 1; however, it will be understood by those skilled in the art that the principles set forth herein are not limited to the embodiment illustrated therein.

The process **1100** may be used by a CLT **120** or any other intermediate node. The CLT **120** may comprise an LLID filter table **1115** (shown in FIG. 12), which may be used in conjunction with process **1100**. Filter table **1115** includes a plurality of entries **1117**. Each entry of the plurality may comprise a LLID corresponding to a network device on a coaxial portion **152** of a unified optical-coaxial network **100**, for example CNU **130**. In filter table **1115**, LLID1, LLID2, LLID3, . . . , LLIDn are shown by way of example.

Returning to FIG. 11, the process **1100** begins at decision block **1102** where the process **1100** determines whether the LLID in the received frame is a broadcast LLID. A broadcast LLID may be an LLID intended for all devices (e.g. all CNU) in the unified optical-coaxial network. If the LLID is a broadcast LLID, then process **1100** falls through the "Yes" branch to block **1104** where the process **1100** accepts the frame for transmission to one or more downstream CNU, e.g. CNU **130** in FIG. 1. In other words, the frame is not filtered or otherwise prevented from reaching the CNU at the CLT. The determination may be made as described in conjunction with step **502**, FIG. 5. Returning to block **1102**, if the LLID in the received frame is not a broadcast LLID, the process **1100** proceeds by the "No" branch to decision block **1106**.

In block **1106**, process **1100** determines if the received LLID matches a value in an entry of the plurality of entries **1117**. If the LLID matches in block **1106**, process **1100** pro-

11

ceeds by way of the “Yes” branch to block 1104 and the message frame is accepted for transmission. Otherwise, if the LLID does not match in block 1106, process 1100 falls through the “No” branch and the frame is discarded at block 1108.

Refer now to FIG. 13 illustrating flowchart of a process 1200 for filtering message frames in accordance with yet another embodiment of the disclosure. Process 1200 will be described in the context of unified optical-coaxial network 100 shown in FIG. 1; however, it will be understood by those skilled in the art that the principles set forth herein are not limited to the embodiment illustrated therein.

The process 1200 may be used by a CLT 120 or any other intermediate node. The CLT 120 may comprise an LLID filter table 1215 (shown in FIG. 14), which may be used in conjunction with process 1100. Filter table 1215 includes a plurality of entries 1117. Each entry of the plurality may comprise a LLID corresponding to a network device on a coaxial portion 152 of a unified optical-coaxial network 100, for example CNU 130. In filter table 1115, LLID1, LLID2, LLID3, . . . , LLIDn are shown by way of example. Additionally, CLT 120 may comprise a LLID channel profile table 1219 (shown in FIG. 15) including a plurality of entries 1221. Each entry may comprise a LLID index portion 1223 and a channel profile portion 1225. An LLID index portion 1223 may include a LLID; here shown as LLID1, LLID2, LLID3, . . . , LLIDm. The number of entries 1221 need not be the same as the number of entries 1217, nor do the LLIDs in LLID table 1215 necessarily correspond to each LLID in an LLID index portion 1223. Channel profile portions 1225 may include channel PHY profile data for the coaxial portion 152 of the unified optical-coaxial network 100. Channel PHY profile data may include, for example, orthogonal frequency division multiplex (OFDM) modulation order, forward error correction (FEC) coding scheme, power level and the like. Further, a channel profile portion 1225 may be empty, or null, for some entries 1221.

Returning to FIG. 13, the process 1200 begins at decision block 1202 where the process 1100 determines whether the LLID in the received frame matches an LLID in an entry 1217 of table 1215. If there is no match, process 1200 proceeds by the “No” branch and the frame is discarded in block 1204. Otherwise, process 1200 proceeds by the “Yes” branch (a match has been found) to decision block 1206. In block 1206, process 1200 indexes into channel profile table 1219 using the matched LLID. If there is no corresponding entry, process 1200 proceeds by the “No” branch of block 1206, and the frame is discarded at block 1204. If there is a corresponding entry 1221 in channel profile table 1219, process 1200 proceeds by the “Yes” branch to decision block 1208. At block 1208, process 1200 determines if the channel profile portion 1225 of the entry 1221 of the LLID index portion 1223 corresponding to the matched LLID contains channel PHY profile data. Recall that some entries 1221 may comprise a null channel portion 1225. If a profile is found at block 1208, the frame is accepted for transmission at block 1210. Conversely, if no profile is found (the channel profile portion 1225 is empty or null), the frame is discarded at block 1204.

To further appreciate the disclosed embodiments, refer now to FIG. 16 illustrating three downstream message flows 1300a-1300c in accordance with the various embodiments discussed hereinabove. In each of these OLT 110 transmits a message, as described further below, via an ODN 115 and a CLT 120 to a CNU 130 coupled to an EDN 135. Referring now to message flow 1300a, a message 1302 is transmitted from OLT 110 to a CNU 130 via a portion 115a of ODN 115. As discussed in conjunction with FIG. 2, the LNID may be

12

carried in a portion of the LLID field of preamble of an Ethernet frame (field 225) and a CNU ID portion comprising the remaining portion (field 227) of the LLID field (field 226). In this way, both the LNID portion and the CNU ID portion may be assigned to a CNU 130. Message 1302 comprises an LNID portion, LNID1 assigned to CLT 120a, and a CNU ID portion, LLID1 assigned to CNU 130a. As discussed hereinabove, a CLT 120 may have one or more assigned LNID. Here, the CLT is shown with four LNIDs (LNID1-LNID4); however, it would be appreciated that a CLT 120 may, in principle, have any finite number of LNIDs. Different LNIDs assigned to CLT 120a may be associated with different portions of EDN 135; portion 135a is shown as associated with LNID1 and portion 135b as associated with LNID3. Further, it would be understood by those skilled in the art that in accordance with message flow 1300a, another message, addressed to one of CNU 130b or 130c might contain LNID1 and the CNU ID assigned to the corresponding one of CNU 130b and 130c.

Referring now to message flow 1300b, a message 1304 is transmitted from OLT 110 to a CNU 130 via a portion 115b of ODN 115. CLT 120b may be identified by an assigned LNID, here LNIDX. As described in conjunction with FIG. 3, a LNID may be carried in a field of the preamble of an Ethernet frame (e.g. field 304). A LLID assigned to a CNU may also be carried in a field of the Ethernet preamble (e.g. field 306). Thus, CLT 120 may be assigned LNIDX and CNU 130d may be assigned LLIDX. Thus CLT 120b may forward message 1304 to CNU 130d using LLIDX.

Referring now to message flow 1300c, a message 1306 is transmitted to CNU 130f by OLT 110. Message 1306 comprises an LLID, LLID3 assigned to CNU 130f. CLTs 120c may have no LNID assigned. CLTs 120c may broadcast message 1306 to all connected CNU 130, including CNU 130f.

Refer now to FIG. 17 illustrating three upstream message flows 1400a-1400c in accordance with the various embodiments discussed hereinabove. These will be described in the context of unified optical-coaxial network 100 shown in FIG. 1; however, it will be understood by those skilled in the art that the principles set forth herein are not limited to the embodiment illustrated therein. In each of these one or more CNU 130 transmits a message, as described further below, via an EDN 135 and a CLT 120 to an OLT 110 coupled to an ODN 155. An OLT 110 comprises a dynamic bandwidth allocation (DBA) scheduler.

Referring to message flow 1400a, message windows 1402 and 1404 are transmitted from a CNU 130 to an OLT 110. In message flow 1400a, a window on the optical portion 150 of a unified optical-coaxial network may be allocated by the scheduler based on a request by the CLT 120 for respective time slots for each LLID having data and each of the CNU 120's assigned LNID. In other words, a time slot allocation is on per LNID per connected LLID. Thus message 1402 is occupying a time slot allocated to LLID1 connected to LNID1. Similarly, 1404 occupies a time slot allocated to LLID3 connected to LNID3. Both LNID1 and LNID3 may be assigned to CLT 120a.

Referring now to message flow 1400b, time slots are allocated on a per LNID basis. Thus, the three windows 1406, 1408, and 1410 may comprise time allocations to LIND1, LIND2, and LINDX, respectively. Messages occupying those time slots may comprise data from one or more CNU 130 connected to the corresponding LNID, shown here assigned to respective CLTs 120b.

Referring now to message flow 1400c, time slots are allocated on a per LLID basis. Thus, windows 1412, 1414, and 1416 may comprise time allocations to LLID1, LLID3, and

13

LLID2, independent of any LNID to which the corresponding CNU 130 may be connected, or if an LNID has been assigned to a CLT 120, for example CLT 120c.

To further appreciate the unified optical-coaxial network 100, refer now to FIG. 18 illustrating unified optical-coaxial networks 1500a, 1500b, and 1500c representing various deployment environments in accordance with embodiments of the disclosure. Unified optical-coaxial network 1500a comprises an OLT 110 which may be located at a hub or head end facility coupled to CLT 120 via ODN 115. Each of OLT 110 and CLT 120 may comprise a processor and other logic (not shown) configured to manage and allocate upstream bandwidth in accordance with embodiments disclosed hereinabove. Further, CLT 120 may, for example, include a processor and other logic (not shown) configured buffer upstream traffic and forward the traffic to OLT 110 during a time window allocated by the OLT 110 as described in conjunction with embodiments disclosed above.

CLT 120 may be coupled to subscriber devices such as cable modem (CM) 1502 and CNU 130. It would be appreciated that subscriber devices CM 1502 and CNU 130 are provided by way of example, and other types of subscriber devices may be connected to CLT 120. As described in conjunction with FIG. 1, CNU 130 also may act as an intermediary between OLT 110 and subscriber devices such as a personal computer, television, set-top box and the like (not shown in FIG. 18). CLT 120 may be coupled to the CNU 130 and CM 1502 via Electrical Distribution Network (EDN) 135 which may comprise splitter 137. Further, in unified optical-coaxial network deployment 1500a EDN 135 may comprise passive coaxial cables.

Unified optical-coaxial network 1500b may comprise a unified optical-coaxial network deployment through amplifiers in conjunction with cable television CATV services 1506. In unified optical-coaxial network 1500b, OLT 110 is coupled to CLT 120 through ODN 115. ODN 115 may carry (CATV) services 1506 via multiplexer 1508, which multiplexes CATV signals onto fiber 1503. Additionally, multiplexer 1508 may multiplex signals from OLT 110 onto fiber 1503. CATV signals multiplexed onto fiber 1503 may comprise amplitude modulated (AM) analog signals, while signals from OLT 110 multiplexed onto fiber 1503 may comprise digital signals. ODN 115 may include a splitter 117 which may split the digital signals from OLT 110 and analog signals from CATV services 1506 on fiber 1503 and couples these signals to CLT 120 and hybrid fiber-coaxial (HFC) node 1504, respectively. Traditionally, HFC networks have been used to carry CATV services, but it would be appreciated that other services such as high-speed data services and telephony services may also be carried.

EDN 135 may couple signals from CLT 120 and HFC node 1504 to subscriber devices such as CNU 130, CM 1502, and set-top box (STB) 1509. Again, CNU 130, CM 1502, and STB 1509 are shown by way of example and it would be appreciated that other types of subscriber devices may be coupled to CLT 120. Electrical signals from CLT 120 and HFC node 1504 may comprise signals in distinct frequency bands and may be combined on EDN 135. For example electrical signals from CLT 120 may comprise digital signals in a band of about 800 Megahertz (MHz) to about 1 Gigahertz (GHz) and electrical signals from HFC 1504 may comprise analog signals in a band from about 85 MHz to about 750 MHz. However, it would be understood by those skilled in the art that the aforementioned frequency bands are provided by way of illustration and the principles of the disclosure are not limited to these bands.

14

EDN 135 may further comprise splitters 137 and amplifiers 1510. Amplifiers 1510 may be included in EDN 135 to mitigate against attenuation of electrical signals carried thereon. It would be recognized by those skilled in the art that, in various embodiments, the number of amplifiers 1510 used may be different or an embodiment may not use any amplifiers 1510.

Unified optical-coaxial network 1500c comprises a unified optical-coaxial architecture in which a CLT 120 may be located in a hub/head end facility and digital signals form the CLT 120 overlay an HFC portion 1512 which provides an intermediate optical fiber link, optical fiber 1514. Digital electrical signals from CLT 120 may be amplitude modulated onto an optical signal by optical transceiver 1518. Video signals from CATV services 1506 may also be amplitude modulated onto the optical signal by transceiver 1518 and transmitted to HFC node 1504. HFC node 1504 may convert optical signals received on optical fiber 1514 to electrical signals for transmission via EDN 135 to subscriber devices such as CM 1502, CNU 130, and STB 1509. CM 1502, CNU 130, and STB 1509 again as provided in unified optical-coaxial network 1500c are by way of example and not intended to limit the disclosed embodiment to those types of devices, as would be understood by those skilled in the art. Electrical signals output by HFC node 1504 may comprise digital electrical signals arising from the aforementioned digital electrical signals from CLT 120, and analog electrical signals arising from CATV services 1506. As described in conjunction with unified optical-coaxial network 1500b, these respective electrical signals may comprise signals in distinct frequency bands.

At least some of the features/methods described in the disclosure may be implemented in a network apparatus or component, such as a network nodes or units described herein. For instance, the features/methods of the disclosure may be implemented using hardware, firmware, and/or software installed to run on hardware. The network apparatus/component or unit may be any device that transports frames through a network, e.g., a switch, router, bridge, server, etc. FIG. 19 illustrates an embodiment of a transmitter/receiver unit 1600, in which the disclosed methods and systems may be implemented. The transmitter/receiver unit 1600 may be any device that transports data through the network. The network unit 1600 may comprise one or more ingress ports or units 1610 coupled to a receiver (Rx) 1612 for receiving signals and frames/data from other network components. The network unit 1600 may comprise a logic unit 1620 to determine to which network components to send data. The logic unit 1620 may be implemented using hardware, software, firmware, or combinations thereof. Specifically, the logic unit 1620 may include a processor (which may be referred to as a central processor unit or CPU) that is in communication with memory devices 1622, including read only memory (ROM) and/or random access memory (RAM). The logic unit 1620 may be implemented as one or more general-purpose CPU chips running software stored in memory 1622, or may be part of one or more application specific integrated circuits (ASICs) and/or digital signal processors (DSPs). The network unit 1600 may also comprise one or more egress ports or units 1630 coupled to a transmitter (Tx) 1632 for transmitting signals and frames/data to the other network components. The components of the network unit 1600 may be arranged as shown in FIG. 19.

At least one embodiment is disclosed and variations, combinations, and/or modifications of the embodiment(s) and/or features of the embodiment(s) made by a person having ordinary skill in the art are within the scope of the disclosure.

15

Alternative embodiments that result from combining, integrating, and/or omitting features of the embodiment(s) are also within the scope of the disclosure. Where numerical ranges or limitations are expressly stated, such express ranges or limitations should be understood to include iterative ranges or limitations of like magnitude falling within the expressly stated ranges or limitations (e.g., from about 1 to about 10 includes, 2, 3, 4, etc.; greater than 0.10 includes 0.11, 0.12, 0.13, etc.). For example, whenever a numerical range with a lower limit, R_l , and an upper limit, R_u , is disclosed, any number falling within the range is specifically disclosed. In particular, the following numbers within the range are specifically disclosed: $R = R_l + k \cdot (R_u - R_l)$, wherein k is a variable ranging from 1 percent to 100 percent with a 1 percent increment, e.g., k is 1 percent, 2 percent, 3 percent, 4 percent, 5 percent, . . . 50 percent, 51 percent, 52 percent, . . . , 95 percent, 96 percent, 97 percent, 98 percent, 99 percent, or 100 percent. Moreover, any numerical range defined by two R numbers as defined in the above is also specifically disclosed. The use of the term about means $\pm 10\%$ of the subsequent number, unless otherwise stated. Use of the term "optionally" with respect to any element of a claim means that the element is required, or alternatively, the element is not required, both alternatives being within the scope of the claim. Use of broader terms such as comprises, includes, and having should be understood to provide support for narrower terms such as consisting of, consisting essentially of, and comprised substantially of. Accordingly, the scope of protection is not limited by the description set out above but is defined by the claims that follow, that scope including all equivalents of the subject matter of the claims. Each and every claim is incorporated as further disclosure into the specification and the claims are embodiment(s) of the present disclosure. The discussion of a reference in the disclosure is not an admission that it is prior art, especially any reference that has a publication date after the priority date of this application. The disclosure of all patents, patent applications, and publications cited in the disclosure are hereby incorporated by reference, to the extent that they provide exemplary, procedural, or other details supplementary to the disclosure.

While several embodiments have been provided in the present disclosure, it should be understood that the disclosed systems and methods might be embodied in many other specific forms without departing from the spirit or scope of the present disclosure. The present examples are to be considered as illustrative and not restrictive, and the intention is not to be limited to the details given herein. For example, the various elements or components may be combined or integrated in another system or certain features may be omitted, or not implemented.

In addition, techniques, systems, subsystems, and methods described and illustrated in the various embodiments as discrete or separate may be combined or integrated with other systems, modules, techniques, or methods without departing from the scope of the present disclosure. Other items shown or discussed as coupled or directly coupled or communicating with each other may be indirectly coupled or communicating through some interface, device, or intermediate component whether electrically, mechanically, or otherwise. Other examples of changes, substitutions, and alterations are ascertainable by one skilled in the art and could be made without departing from the spirit and scope disclosed herein.

What is claimed is:

1. A method implemented in a coaxial line terminal (CLT), the method comprising:
registering the CLT with an optical line terminal (OLT) via an optical portion of a network, wherein the registering

16

comprises receiving a first logical link identifier (LLID) that is a broadcast LLID for the OLT;

receiving, from a coaxial network unit (CNU) via a coaxial portion of the network and subsequent to the registering, a CNU register request message addressed to the OLT and comprising the first LLID;

forwarding the CNU register request message to the OLT; and

forwarding, by the CLT, a CNU register message from the OLT to the CNU in response to forwarding the CNU register request message, the CNU register message comprising the first LLID, a second LLID assigned by the OLT to the CNU, and a logical node identifier (LNID) assigned by the OLT to the CLT.

2. The method of claim 1, wherein forwarding the CNU register request message comprises forwarding the CNU register request message when a time window opens, and wherein the time window is allocated to the first LLID.

3. The method of claim 2, wherein the registering comprises:

receiving, from the OLT, a gate message comprising the first LLID; and

transmitting to the OLT a CLT register request message in an OLT discovery window.

4. The method of claim 3, wherein the first LLID comprises a base LLID for the coaxial portion of the network.

5. The method of claim 3, further comprising intermediating between the OLT via the optical portion of the network and the CNU via the coaxial portion of the network.

6. The method of claim 1, wherein forwarding the CNU register request message comprises forwarding the CNU register request message in a time window allocated to a base LLID for the coaxial portion of the network.

7. The method of claim 1, wherein forwarding the CNU register request message comprises forwarding the CNU register request message in a discovery window allocated by the OLT.

8. The method of claim 7, wherein the LNID identifies the CNU.

9. The method of claim 8, wherein the registering further comprises receiving, from the OLT, a CLT register message comprising the LNID.

10. An optical line terminal (OLT) comprising:

a processor configured to:

register a coaxial line terminal (CLT) using a first logical link identifier (LLID) that is a broadcast LLID for the OLT and using a logical node identifier (LNID) assigned by the OLT to the CLT, wherein the CLT intermediates between the OLT via an optical portion of a unified optical-coaxial network and a coaxial network unit (CNU) via an electrical network portion of the unified optical-coaxial network;

process a register request message originating from the CNU and comprising the first LLID;

assign a second LLID to the CNU;

register the CNU; and

generate a CNU register message comprising the first LLID, the second LLID, and the LNID; and

a transmitter coupled to the processor and configured to transmit the CNU register message to the CNU via the CLT.

11. The OLT of claim 10, wherein the transmitter is further configured to transmit the LNID to the CLT in a CLT register message.

12. The OLT of claim 11, wherein the processor is further configured to generate a payload of a multipoint control protocol (MPCP) gate message comprising the first LLID.

17

13. The OLT of claim 11, wherein the processor is further configured to:

assign to the CLT a third LLID that is a unicast LLID for the CLT; and

allocate a timeslot to the CNU via a unicast channel. 5

14. The OLT of claim 13, wherein the processor is further configured to generate a multipoint control protocol (MPCP) gate message comprising the timeslot, and wherein the transmitter is further configured to transmit the MPCP gate message towards the CNU. 10

15. A coaxial network unit (CNU) comprising:

a receiver configured to receive an access time allocation from a coaxial line terminal (CLT);

a processor coupled to the receiver and configured to: 15

process the access time allocation;

establish a link between the CNU and the CLT on a coaxial portion of a unified optical-coaxial network using the access time allocation; and

generate a register request message; and 20

a transmitter coupled to the processor and configured to transmit the register request message to an optical line terminal (OLT) via the CLT subsequent to the receiver receiving the access time allocation,

18

wherein the receiver is further configured to receive, from the OLT via the CLT and in response to the register request message, a CNU register message comprising a first logical link identifier (LLID) that is a broadcast LLID for the OLT, a second LLID assigned by the OLT to the CNU, and a logical node identifier (LNID) assigned by the OLT to the CLT.

16. The CNU of claim 15, wherein the transmitter is further configured to transmit the register request message to the OLT in an OLT discovery window.

17. The CNU of claim 15, wherein the transmitter is further configured to transmit the register request message to the OLT in a timeslot allocated to a base LLID for the coaxial portion of the unified optical-coaxial network.

18. The CNU of claim 15, wherein the LNID further identifies the CNU.

19. The CNU of claim 15, wherein the access time allocation indicates a time window for the CNU to transmit the register request message.

20. The CNU of claim 18, wherein the processor is further configured to generate a register acknowledgment, and wherein the transmitter is further configured to transmit the register acknowledgment.

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